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LUMINARY Memo # 65

TO: Distribution
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SUBJECT: A Variable Time Constant Velocity-Nulling Guidance Law

Introduction

The present velocity-nulling guidance law has a fixed time constant. This guidance law is used for the last ten seconds of P64 and all of P65. This fixed gain guidance law is simply

$$\underline{a}_{TD} = (\underline{v}_D - \underline{v}_o)/\tau_v - \underline{g}_o \qquad (1)$$

where

$\underline{a}_{TD}$ the present desired thrust acceleration.

$\underline{g}_o$, $\underline{v}_o$ = the last measured gravitational acceleration vector and velocity vector.

$\underline{v}_D$ = the desired touchdown velocity vector.

τ_v = the fixed time-constant for nulling the velocity error; currently equal to six seconds.

A variable-gain (τ_v not fixed) velocity - nulling guidance law has certain advantages. For example, it is desireable to null the velocity error early and quickly so that there is not much attitude maneuvering near touch-down. Also, with lags in the system (computation lag and FINDCDUW lag chiefly) stabilization

suggests a larger τ_v than one might otherwise choose.

The following guidance law has time-varying gains and guidance command projection. It is analytically derived later.

$$T_{go} = T - t_o$$

$$T_{go}^{*} = T_{go} - \tau$$

$$R = T_{go}^{*}/T_{go}$$

$$\underline{a}_{TD} = n R^{n-1}(\underline{v}_D - \underline{v}_o)/T_{go} - \underline{g}_o \qquad (2)$$

Equation (2) is more complicated than (1) but only marginally so and it is much simpler than Equation 15 in LUMINARY Memo #63, which is used in the guidance phase immediately preceding the velocity-nulling phase.

The quantity n is any positive non-zero integer. The best value for n is yet to be determined. From inspection it can be seen that the larger n, the larger, relatively speaking, is the gain at large values of T_{go} and the earlier the velocity error is nulled. We can analytically relate the stationariness of the commanded thrust acceleration at $t = T$, the touchdown time, to the order of n.

Equation (2) has not been tested in simulations yet but its relative simplicity, time-varying gains, and guidance command projection recommend its investigation. Both MIT/IL and MSC/G&C have noted oscillations with the present law, Eq. (1).